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Final Technical Report

ONR Grant Number: N00014-89-J-1040

Title: Specifying, Predicting, and Verifying the Timing Properties of Hard-Real-Time Programming Languages and Systems

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The major research accomplishments supported by the grant were:

1. Predicting the Deterministic Timing Behavior of Programs [1, 2, 5, 6, 8, 9, 12].
   Much work was done in developing concepts and techniques to predict the deterministic execution times of sequential and parallel programs. This also included substantial experimental work and the construction of software tools to validate our ideas and methodology, especially for sequential programs. The basis for this work was our notion of source program timing schema that provided a machine-independent timing semantics for higher-level language software.

2. Specifying Requirements and Designs for Real-Time Systems [3].
   A new specification method, called communicating real-time state machines, was invented for describing requirements and designs of distributed real-time systems. The principal novel feature of the method was the facility to specify timing properties. A prototyping environment including a simulator, assertion checker, and graphics front end was recently completed.

3. Other Research
   We designed a methodology for the software engineering of real-time operating systems, based on a straightforward process/abstract-data-type (object) model, and built an operating system kernel using our scheme [7]. Some new results in deterministic scheduling theory were proven and a software design model – the producer/consumer paradigm – that permits reasoning about timing behaviors when IO rates are available was developed [10, 11]. Time-sensitive objects were defined and proposed as a basis for the design of real-time cyclic control systems [4].

Two Ph.D.'s were completed with support from the grant [1, 11]. Park has a Post-Doctoral research appointment at the University of Michigan. Jeffay is an Assistant Professor at the University of North Carolina.

References

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3. A. Shaw, "Communicating Real-Time State Machines," Tech. Report 91-08-09, Dept. of Computer Science & Engineering, Univ. of Washington, Aug. 1991 (A revised version is in publication in *IEEE Trans. on Software Engineering*, Sept. 1992).

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12. C. Park and A. Shaw, "A Source-Level Tool for Predicting Deterministic Execution Times of programs," Tech. Report 89-09-12, Dept. of Computer Science & Engineering, Univ. of Washington, Sept. 1989.